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VIA E-MAIL: Robinson.Jeffery@epa.gov

August 30, 2018

Mr. Jeff Robinson
Air Permits Section Chief
Environmental Protection Agency, Region 6
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

Re: TGTI Initial Response to NSR Air Permit Completeness Determination - Questions 1, 4, 6, 8, 9, 10

Dear Mr. Robinson:

Texas Gulf Terminals Inc. (TGTI) submitted a New Source Review (NSR) Air Permit Application as part of the TGTI project to obtain a license for the operation of a Deepwater Port (DWP) in Federal waters of the U.S. Gulf of Mexico. On August 10, 2018, TGTI received a letter from Environmental Protection Agency (EPA) requesting additional information to support the NSR Permit Application Completeness Review. TGTI's responses to EPA's questions are provided in this letter.

The following attachments are provided in support of TGTI's responses to the request for additional information:

Attachment 1 – TGTI Crude Composition Data
Attachment 2 – Detailed Emission Calculations for Crude Vapor Speciation
Attachment 3 – GHG Emissions Calculation for Marine Loading and SPM Fugitives
Attachment 4 – Comparison of Crude/Condensate Emissions between Equations 1 and 2 of AP-42 Chapter 5.2
Attachment 5 – Reference for Equation 3 of AP-42 Chapter 5.2

The responses below are numbered corresponding to the questions in the August 10, 2018 letter. This letter answers questions 1, 4, 6, 8, 9, and 10 of the letter. TGTI is in the process of compiling the information necessary to respond to Questions 2, 3, 5, and 7 and will submit a separate letter in response to the questions not answered in this letter.

EPA Question 1

Please provide additional supporting technical documentation to allow for the verification of the basis for the emission calculations. Specifically, we are requesting data regarding the true vapor pressure of the crude oil (psia), molecular weight of vapors (lb/lb-mole), material composition data of the associated emissions (speciated) for the crude oil/condensate proposed to be used for the export operation.

<u>*TGTI Response:*</u>
The crude composition data obtained from TGTI is provided in Attachment 1. Detailed emission calculations for crude vapor speciation are provided in Attachment 2. The speciated vapor weight percentages are calculated based on Raoult's law and are detailed in the TGTI's response to Question No. 10 below.

As a conservative assumption, the properties of gasoline were used to represent condensate in the hourly and annual emission calculations. As shown in Attachment 1, the maximum reid vapor pressure (RVP) of crude from the crude profiles in 8.8 psia. The annual emissions from condensate are conservatively based on an annual average RVP of 13.5 psia, which is equivalent to a TVP of 9.25 psia. A maximum true vapor pressure (TVP) of 11 psia is used to calculate hourly emissions from condensate. For crude oil, the hourly and annual emissions are based on a maximum TVP of 11 psia and an annual average TVP of 11 psia. The TVP values used in the calculations are conservative because the TVP of crude is dependent on temperature and will not always be at the maximum vapor pressure.

Different molecular weights for the hourly and annual condensate emissions are used because the molecular weight of gasoline (which is used to represent condensate) varies with vapor pressure. Different RVP gasolines have different molecular weights. This is consistent with Table 7.1-2 of AP-42 Chapter 7.1, where the molecular weight of gasoline ranges from 60 – 68 lb/lb-mole for gasoline RVPs ranging from 7 – 15 psia.

EPA Question 4

On page 9-5 of the PSD permit application, TGTI asserts that the SPM buoy operation will comply with all applicable requirements in 30 TAC 111, Control of Air Pollution from Visible Emissions and Particulate Matter. For the permitting record, please specify, if possible, the specific provisions in 30 TAC 111 that TGTI is proposing to comply with meet and the associated method of compliance and/or monitoring to assure continuous compliance.

TGTI Response:
The proposed SPM buoy system will comply with 30 TAC §111 requirements for visible emissions from the proposed operations. The nature of the emissions generated by the proposed SPM buoy system are the exhaust of organic vapors through the loading of the marine vessel tanks. The proposed SPM buoy system will not emit particular matter emissions nor visible emissions through the loading of the marine vessel tanks. Therefore, it is not a reasonable expectation that there will be visible emissions from the operation of the proposed SPM buoy system. As such, TGTI proposes that the inherent nature of emissions from the process are sufficient to provide reasonable assurance that the SPM buoy will remain in continuous compliance with the applicable provisions of 30 TAC §111.

EPA Question 6

Please provide your calculations for Greenhouse Gas (GHG) emissions from the SPM buoy and marine loading operation based on the gas speciation analysis from the crude/condensate to be exported. If the resulting GHG emissions level is equal to or greater than 75,000 tpy of CO2e, a five-step BACT analysis for GHG emissions associated with marine loading operations will be needed. [40 CFR 52.21(b)(49)(iv)(a)].

TGTI Response:
Based on the crude composition data obtained from TGTI, the calculated average vapor weight percent for methane and ethane combined is 26%. The methane and ethane combined weight percentage is used to conservatively estimate the annual methane emissions from the SPM buoy and marine loading operations. The resulting methane emissions estimate is multiplied by the methane global warming potential (GWP) of 25 based on Appendix A, Table A-1 of 40 CFR Part 98 to obtain the conservative estimate of CO_2e emissions. As shown in the detailed emissions calculations provided in Attachment 3, the estimated GHG emissions from the SPM buoy and marine loading operation will be less than 75,000 tpy of CO_2e.

EPA Question 8

The calculations for the hourly and annual VOC emission calculations rely on U.S. EPA AP-42 emission factors, Section 5.2 (7/08), Table 5.2-1, equation 1. The footnote to Table 5.2-1 states that equations 2 and 3 should be used to estimate emissions from marine loading operation of crude oil -not equation 1. Please provide additional information to support the use of equation 1 to determine the Saturation Factor rather than equations 2 and 3.

<u>*TGTI Response:*</u>
The use of Equation 1 and saturation factor from Table 5.2-1 provides the worst-case emissions from the proposed source. A comparison of crude oil and condensate loading emissions between Equations 1 and 2 is provided in Attachment 4.

Additionally, TGTI reviewed the equations EPA suggested and determined them not to be applicable for estimating emissions from the loading of very large crude carriers (VLCCs). The reference that EPA cites for Equation 3 in AP-42 Chapter 5.2, (provided as Attachment 5) "*Atmospheric Hydrocarbon Emissions From Marine Vessel Transfer Operations, Publication 2514A, American Petroleum Institute, Washington, DC, 2009*" states that the derived equation should not be used to estimate evaporative losses from VLCCs or ultra large crude carriers (ULCCs) unless the saturation factor K_S is determined. Further, TCEQ has requested the use of Equation 1 over Equation 2/3 in recent permitting actions.

EPA Question 9

In comparing the calculations for the hourly and annual VOC emission calculations, it is unclear why different condensate physical properties were used in the calculations. For example: Hourly Condensate Vapor MW = 60 lb/lb-mol and the Annual Condensate Loading MW = 62 lb/lb-mol. Differences may also be found in the Maximum True Vapor Pressure (TVP). Please provide any technical details on why different condensate physical properties were used in the calculations.

<u>*TGTI Response:*</u>
The properties of gasoline were used to represent condensate in the hourly and annual emission calculations. A maximum TVP of 11 psia is used to calculate hourly emissions from condensate. The annual emissions from condensate are based on an annual average RVP of 13.5 psia, which is equivalent to a TVP of 9.25 psia. For crude oil, the hourly and annual emissions are based on a maximum TVP of 11 psia and an annual average TVP of 11 psia. The TVP values used in the calculations are based on conservative assumptions.

Different molecular weights for the hourly and annual condensate emissions are used because the molecular weight of gasoline (which is used to represent condensate) varies with vapor pressure. Different RVP gasolines have different molecular weights. This is consistent with Table 7.1-2 of AP-42 Chapter 7.1, where the molecular weight of gasoline ranges from 60 – 68 lb/lb-mole for gasoline RVPs ranging from 7 – 15 psia.

EPA Question 10

Please provide additional information related to the mixture representation used in the TANKS 4.09d program for condensate and how this information correlates with the HAP speciation profile.

<u>*TGTI Response:*</u>
The crude composition data obtained from TGTI is provided in Attachment 1. Benzene and toluene are the

two HAPs identified from these profiles. A summary of HAP speciation obtained from the crude profiles is shown in Table 1 below.

Table 1. TGTI Crude Assays HAP Speciation (Liquid wt%)

Profiles	Benzene	Toluene
1	0.22	0.61
2	0.65	2.74
3	0.76	0.32
4	0.15	1.37
5	0.24	0.47

The speciated vapor weight percentages are calculated based on the following steps.

First, liquid mole fraction (l_i) is calculated using the maximum liquid weight percent (W_i) from the crude profiles provided in Attachment 1 using the following equation.

$$l_i = (W_i / M_i) / \Sigma (W_i / M_i)$$

where l_i = liquid mole fraction of component i
M_i = liquid molecular weight of component i, lb/lbmol
W_i = liquid weight percent of component i

Second, partial pressure of the individual components is estimated using Raoult's law. According to Raoult's Law, the partial pressure of a component is the product of its pure component vapor pressure and its liquid mole fraction. The sum of the partial pressures is equal to the total vapor pressure of the mixture.

The pure component vapor pressures are calculated using the Antoine's equation.

$$\text{Log } P = A - B / (T + C)$$

where P = vapor pressure, mmHg
T = temperature, °C
A, B, and C = component-specific constants

Using the Antoine's coefficients for benzene as an example, A = 6.905, B = 1211.033 and C = 220.790, the pure component vapor pressure comes out to be 1.68 psia at 23 °C. In order to calculate the mixture vapor pressure, the partial pressures need to be calculated for each component. The partial pressure is the product of the pure component vapor pressure of each component (calculated above) and the mole fraction of each component in the liquid as calculated in step 1.

Third, the vapor mole fractions of the components are calculated. The vapor mole fraction, y_i, is equal to the partial pressure of the component divided by the total partial pressure of the mixture.

$$y_i = P_{partial} / P_{total}$$

where y_i = vapor mole fraction of component i
$P_{partial}$ = partial pressure of component i

P_{total} = total partial pressure of the mixture

Fourth, the molecular weight of the vapor, M_V is calculated. Molecular weight of the vapor depends upon the mole fractions of the individual components in the vapor.

$$M_{Vi} = \Sigma M_i y_i$$

where M_{vi} = vapor molecular weight of component i
M_i = liquid molecular weight of component i
y_i = vapor mole fraction of component i

Finally, vapor weight fraction (W_i) of the component is the product of the molecular weight of the component (M_i) and vapor mole fraction (y_i) divided by the summation of the products of the molecular weight of the components and their vapor mole fractions.

$$W_i = M_i y_i / \Sigma M_i y_i$$

Based on the approach explained above, the average vapor weight fractions of components in the crude profiles at 73.5 °F are calculated and the maximum HAP vapor speciation is summarized below. Detailed emission calculations for vapor speciation are provided in Attachment 2.

Table 2. HAP Speciation based on Crude profiles provided by TGTI

HAP	Max Single HAP Vapor wt%	Max Total HAP Vapor wt%
Benzene	0.24%	0.53%
Toluene	0.30%	

A conservative approach was employed that assumed benzene and toluene were the only components present in the crude and by applying a 100% safety factor to the benzene and toluene liquid weight fraction from the TGTI crude profiles. The resulting vapor weight fractions for benzene and toluene used in the DWP license application are summarized in Table 3 below. Please note that the HAP vapor weight percentages used in the DWP application (Table 3) are conservative since they are significantly higher than the HAP vapor weight fractions calculated based on the TGTI crude profiles (Table 2).

Table 3. HAP Speciation used in the Application

HAP	Max Single HAP Vapor wt%	Max Total HAP Vapor wt%
Benzene	0.95%	1.93%
Toluene	0.98%	

If you have any questions, comments, or need additional information, do not hesitate to contact me at (972) 661-8100 or Denise Rogers at (832) 203-6493.

Sincerely,

TRINITY CONSULTANTS

Brian Burdorf

Brian Burdorf
Director

cc: Denise Rogers, Compliance Manager - TGTI

ATTACHMENT 1 - TGTI CRUDE COMPOSITION DATA

Reference: **Crude 1**
Crude: **Crude 1**

Crude Summary Report

General Information	
Reference:	Crude 1
Name:	Crude 1
Traded Crude:	Unknown
Origin:	United States of /
Sample Date:	-
Assay Date:	-
Issue Date:	-
Comments:	-

Molecules (%wt on crude)	
methane + ethane	0.02
propane	0.21
isobutane	0.20
n-butane	1.15
isopentane	1.18
n-pentane	1.70
cyclopentane	0.08
C_6 paraffins	1.06
C_6 naphthenes	0.24
benzene	0.22
C_7 paraffins	2.21
C_7 naphthenes	0.87
toluene	0.61

Whole Crude Properties	
Density @ 15°C (g/cc)	0.817
API Gravity	41.60
Total Sulphur (% wt)	0.25
Pour Point (°C)	-26.39
Viscosity @ 20°C (cSt)	8.82
Viscosity @ 40°C (cSt)	4.89
Nickel (ppm)	0.5
Vanadium (ppm)	1.0
Total Nitrogen (ppm)	177
Total Acid Number (mgKOH/g)	0.03
Mercaptan Sulphur (ppm)	20.3
Hydrogen Sulphide (ppm)	0.0
Reid Vapour Pressure (psi)	8.8

Cut Data		Atmospheric Cuts									Vacuum Cuts			
Start (°C)	IBP	C5	65	100	150	200	250	300	350	370	370	450	500	550
End (°C)	FBP	65	100	150	200	250	300	350	370	FBP	450	500	550	FBP
Yield (% wt)		3.9	3.4	9.5	9.3	9.9	9.9	9.5	3.6	39.5	13.5	7.5	6.5	11.9
Yield (% vol)		4.9	3.9	10.4	9.9	10.1	9.8	9.2	3.5	36.0	12.8	6.9	5.9	10.4
Cumulative Yield (% wt)		1.6	5.4	8.8	18.4	27.7	37.6	47.5	56.9	60.5	60.5	74.1	81.5	88.1
Volume Average B.P. (°C)	308	39	91	128	175	225	275	325	360	500	409	474	524	616
Density @ 15°C (g/cc)	0.817	0.638	0.714	0.748	0.768	0.797	0.823	0.842	0.852	0.896	0.866	0.887	0.902	0.936
API Gravity	41.6	90.2	66.7	57.6	52.7	45.9	40.4	36.4	34.6	26.3	31.9	28.0	25.3	19.5
UOPK	12.4			12.0	12.1	12.1	12.1	12.2	12.3	12.5	12.4	12.4	12.5	12.5
Molecular Weight (g/mol)				117	149	184	224	271	309	460	364	446	511	627
Total Sulphur (% wt)	0.247	0.002	0.005	0.008	0.016	0.040	0.098	0.202	0.275	0.51	0.345	0.444	0.54	0.73
Mercaptan Sulphur (ppm)	20.3	2.1	15.8	22.0	27.8	26.8	18.8							
Total Nitrogen (ppm)	177					2	4	15	35	441	112	310	512	858
Basic Nitrogen (ppm)	119.61					0.7042	2.7875	8.4895	15.961	298.61	38.448	100.68	201.42	770.76
Total Acid Number (mgKOH/g)	0.03	0.00	0.00	0.00	0.01	0.02	0.02	0.04	0.04	0.06	0.06	0.07	0.07	0.06
Viscosity @ 20°C (cSt)	8.82				2.47									
Viscosity @ 40°C (cSt)	4.89				1.74	2.69	4.36	7.58	11.8					
Viscosity @ 50°C (cSt)	3.82					2.25	3.55	5.90	8.81	90.2	16.5	47.2	140	
Viscosity @ 60°C (cSt)										56.4	12.2	31.4	83.6	
Viscosity @ 100°C (cSt)										13.9	4.65	9.24	18.3	114
Viscosity @ 130°C (cSt)														35.7
RON (Clear)	24.9	77.7	51.0	52.6	39.0									
MON (Clear)	36.8	77.2	50.2	48.5	37.1									
Paraffins (% wt)	41.6	97.9	70.0	57.6	46.1									
Naphthenes (%wt)	35.1	2.1	23.6	25.5	30.9									
Aromatics (% wt)	23.3	0.0	6.4	16.9	23.1									
Pour Point (°C)	-26					-45	-22	1	12	15	28	43	51	26
Cloud Point (°C)						-42	-20	3						
Freeze Point (°C)					-61	-39	-16							
Smoke Point (mm)					27	21	16							
Cetane Index					50	56	62	70	77					
Naphthalenes (% vol)					0.0839	2.2615	7.2394	12.325						
Aniline Point (°C)				48.5	54.8	64.9	74.8	84.6	91.4		100.9	111.6	118.0	
Hydrogen (% wt)		16.6	15.2	14.5	14.4	13.9	13.5	13.2	13.1		12.9	12.8	12.7	
Wax (% wt)	10.7									19.6	23.5	24.6	21.1	11.2
C_7 Asphaltenes (% wt)	0.1									0.2		0.0	0.0	0.6
Micro Carbon Residue (% wt)	0.4									1.0		0.1	0.6	2.8
Rams. Carbon Residue (% wt)	0.3									0.9		0.1	0.5	2.5
Vanadium (ppm)	1.0									2.6		0.0	0.0	8.5
Nickel (ppm)	0.5									1.3		0.0	0.0	4.4
Iron (ppm)	51.0									129.2		0.0	0.0	427.3

Reference: **Crude 2**
Crude: **Crude 2**

Crude Summary Report

General Information		Molecules (%wt on crude)		Whole Crude Properties	
Reference:	Crude 2	methane + ethane	0.00	Density @ 15°C (g/cc)	0.735
Name:	Crude 2	propane	0.52	API Gravity	60.88
Traded Crude:	Unknown	isobutane	0.83	Total Sulphur (% wt)	0.01
Origin:	Unknown	n-butane	1.89	Pour Point (°C)	-19.71
Sample Date:	12 May 2017	isopentane	2.36	Viscosity @ 20°C (cSt)	1.05
Assay Date:	18 May 2017	n-pentane	3.38	Viscosity @ 40°C (cSt)	0.81
Issue Date:	-	cyclopentane	0.00	Nickel (ppm)	0.0
Comments:	-	C_6 paraffins	3.64	Vanadium (ppm)	0.0
		C_6 naphthenes	6.54	Total Nitrogen (ppm)	7
		benzene	0.65	Total Acid Number (mgKOH/g)	0.03
		C_7 paraffins	8.02	Mercaptan Sulphur (ppm)	8.0
		C_7 naphthenes	5.14	Hydrogen Sulphide (ppm)	0.0
		toluene	2.74	Reid Vapour Pressure (psi)	8.0

Cut Data		Atmospheric Cuts									Vacuum Cuts			
Start (°C)	IBP	C5	65	100	150	200	250	300	350	370	370	450	500	550
End (°C)	FBP	65	100	150	200	250	300	350	370	FBP	450	500	550	FBP
Yield (% wt)		7.4	19.4	27.1	15.2	9.8	6.8	4.6	1.4	5.0	3.4	0.9	0.4	0.3
Yield (% vol)		8.5	19.7	26.7	15.2	9.5	6.4	4.2	1.2	4.3	2.9	0.8	0.4	0.2
Cumulative Yield (% wt)		3.3	10.7	30.0	57.2	72.3	82.2	89.0	93.6	95.0	95.0	98.4	99.3	99.7
Volume Average B.P. (°C)	154	39	85	123	173	224	273	323	360	436	404	472	522	596
Density @ 15°C (g/cc)	0.735	0.636	0.723	0.747	0.731	0.762	0.788	0.810	0.826	0.860	0.845	0.877	0.902	0.944
API Gravity	60.9	91.1	64.1	57.9	61.9	54.1	48.1	43.0	39.8	32.9	36.0	29.8	25.2	18.3
UOPK	12.5			12.0	12.7	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.5	12.3
Molecular Weight (g/mol)				113	151	187	228	276	315	396	364	446	507	593
Total Sulphur (% wt)	0.010	0.000	0.001	0.002	0.003	0.007	0.015	0.031	0.049	0.105	0.077	0.129	0.175	0.248
Mercaptan Sulphur (ppm)	8.0	1.4	7.1	8.3	9.0	7.9	5.6							
Total Nitrogen (ppm)	7					3	8	13	19	112	46	130	242	625
Basic Nitrogen (ppm)	4.523					1.0709	3.6077	9.0155	15.216	69.956	27.152	60.412	117.89	525.24
Total Acid Number (mgKOH/g)	0.03	0.00	0.00	0.01	0.01	0.02	0.04	0.05	0.06	0.07	0.07	0.08	0.07	0.06
Viscosity @ 20°C (cSt)	1.05				1.53									
Viscosity @ 40°C (cSt)	0.81				1.13	1.81	3.06	5.41	8.71					
Viscosity @ 50°C (cSt)	0.73					1.56	2.55	4.35	6.72	22.0	12.4	43.2	156	
Viscosity @ 60°C (cSt)										15.9	9.32	29.2	92.8	
Viscosity @ 100°C (cSt)										5.74	3.90	8.90	20.0	114
Viscosity @ 130°C (cSt)														36.2
RON (Clear)	50.7	76.7	61.4	59.5	38.5									
MON (Clear)	51.1	76.5	58.9	56.3	36.8									
Paraffins (% wt)	52.8	100.0	51.8	53.3	49.2									
Naphthenes (%wt)	29.8	0.0	44.8	25.4	26.5									
Aromatics (% wt)	17.4	0.0	3.4	21.3	24.3									
Pour Point (°C)	-20					-41	-16	8	20	39	33	46	53	-4
Cloud Point (°C)						-38	-14	10						
Freeze Point (°C)					-61	-36	-11							
Smoke Point (mm)					28	24	20							
Cetane Index					72	77	83	88	94					
Naphthalenes (% vol)					0.176	1.336	3.5329	5.7802						
Aniline Point (°C)				46.6	53.1	65.1	76.7	87.8	95.3		103.5	113.9	119.5	
Hydrogen (% wt)		16.7	15.1	14.1	14.2	13.7	13.4	13.3	13.2		13.3	13.2	13.1	
Wax (% wt)	3.5									27.0	28.0	28.4	24.4	15.3
C_7 Asphaltenes (% wt)	0.0									0.1		0.0	0.0	1.2
Micro Carbon Residue (% wt)	0.0									0.5		0.3	1.6	6.1
Rams. Carbon Residue (% wt)	0.0									0.5		0.2	1.5	5.6
Vanadium (ppm)	0.0									0.2		0.0	0.0	3.1
Nickel (ppm)	0.0									0.5		0.0	0.0	8.8
Iron (ppm)	2.2									43.9		0.0	0.0	760.6

Reference: **Crude 3**
Crude: **Crude 3**

Crude Summary Report

General Information		Molecules (%wt on crude)		Whole Crude Properties	
Reference:	Crude 3	methane + ethane	0.03	Density @ 15°C (g/cc)	0.811
Name:	Crude 3	propane	0.41	API Gravity	42.89
Traded Crude:	Unknown	isobutane	0.25	Total Sulphur (% wt)	0.16
Origin:	United States of /	n-butane	1.27	Pour Point (°C)	-23.84
Sample Date:	-	isopentane	1.08	Viscosity @ 20°C (cSt)	5.29
Assay Date:	-	n-pentane	1.63	Viscosity @ 40°C (cSt)	3.27
Issue Date:	-	cyclopentane	0.05	Nickel (ppm)	1.5
Comments:	-	C_6 paraffins	1.88	Vanadium (ppm)	1.7
		C_6 naphthenes	2.95	Total Nitrogen (ppm)	298
		benzene	0.76	Total Acid Number (mgKOH/g)	0.03
		C_7 paraffins	3.68	Mercaptan Sulphur (ppm)	77.0
		C_7 naphthenes	2.05	Hydrogen Sulphide (ppm)	0.0
		toluene	0.32	Reid Vapour Pressure (psi)	6.7

Cut Data		Atmospheric Cuts									Vacuum Cuts			
Start (°C)	IBP	C5	65	100	150	200	250	300	350	370	370	450	500	550
End (°C)	FBP	65	100	150	200	250	300	350	370	FBP	450	500	550	FBP
Yield (% wt)		3.9	9.3	10.7	8.8	9.1	8.7	8.0	3.0	36.5	11.0	5.6	4.3	15.6
Yield (% vol)		4.9	10.3	11.6	9.3	9.3	8.5	7.7	2.9	32.5	10.2	5.1	3.9	13.3
Cumulative Yield (% wt)		2.0	5.9	15.2	25.9	34.7	43.8	52.5	60.5	63.5	63.5	74.5	80.1	84.4
Volume Average B.P. (°C)	304	41	85	125	175	225	275	325	360	563	409	474	524	727
Density @ 15°C (g/cc)	0.811	0.639	0.733	0.743	0.768	0.797	0.821	0.842	0.854	0.911	0.870	0.889	0.896	0.955
API Gravity	42.9	89.8	61.5	59.0	52.8	46.0	40.7	36.5	34.0	23.8	31.0	27.5	26.3	16.6
UOPK	12.5			12.1	12.1	12.1	12.1	12.2	12.2	12.6	12.3	12.4	12.6	12.7
Molecular Weight (g/mol)				115	149	184	224	271	308	508	362	444	513	762
Total Sulphur (% wt)	0.162	0.002	0.003	0.005	0.010	0.025	0.062	0.134	0.188	0.373	0.244	0.314	0.365	0.487
Mercaptan Sulphur (ppm)	77.0	9.9	69.3	108.4	134.5	117.5	70.9							
Total Nitrogen (ppm)	298					2	7	29	66	803	197	517	838	1321
Basic Nitrogen (ppm)	165.3					0.8954	4.1393	13.634	26.062	446.08	58.147	144.05	263.67	876.91
Total Acid Number (mgKOH/g)	0.03	0.00	0.00	0.00	0.01	0.02	0.02	0.04	0.05	0.05	0.06	0.07	0.07	0.04
Viscosity @ 20°C (cSt)	5.29				2.49									
Viscosity @ 40°C (cSt)	3.27				1.74	2.70	4.43	7.86	12.5					
Viscosity @ 50°C (cSt)	2.67					2.25	3.59	6.07	9.20	237	17.4	47.0	110	
Viscosity @ 60°C (cSt)										132	12.7	31.1	66.8	
Viscosity @ 100°C (cSt)										24.2	4.71	8.94	15.2	373
Viscosity @ 130°C (cSt)														85.0
RON (Clear)	28.3	77.3	66.8	52.2	39.0									
MON (Clear)	42.7	77.0	63.9	49.9	37.1									
Paraffins (% wt)	42.4	98.7	47.5	61.5	46.5									
Naphthenes (%wt)	35.6	1.3	44.4	26.3	30.6									
Aromatics (% wt)	22.0	0.0	8.1	12.1	22.9									
Pour Point (°C)	-24					-44	-21	3	15	13	30	45	52	5
Cloud Point (°C)						-42	-19	4						
Freeze Point (°C)					-60	-37	-14							
Smoke Point (mm)					27	21	16							
Cetane Index					50	56	63	70	76					
Naphthalenes (% vol)					0.0423	1.3678	5.5322	10.193						
Aniline Point (°C)				49.2	55.8	66.0	76.1	86.1	93.0		102.5	113.4	119.6	
Hydrogen (% wt)		16.6	14.7	14.7	14.4	13.9	13.5	13.3	13.1		12.9	12.7	12.5	
Wax (% wt)	9.1									18.3	24.3	25.1	23.5	10.1
C_7 Asphaltenes (% wt)	0.2									0.6		0.0	0.0	1.4
Micro Carbon Residue (% wt)	0.7									1.8		0.1	0.6	4.1
Rams. Carbon Residue (% wt)	0.6									1.7		0.1	0.5	3.7
Vanadium (ppm)	1.7									4.6		0.0	0.0	10.8
Nickel (ppm)	1.5									4.0		0.0	0.0	9.4
Iron (ppm)	24.0									65.7		0.0	0.0	153.4

Reference: **Crude 4**
Crude: **Crude 4**

Crude Summary Report

General Information		Molecules (%wt on crude)		Whole Crude Properties	
Reference:	Crude 4	methane + ethane	0.02	Density @ 15°C (g/cc)	0.822
Name:	Crude 4	propane	0.43	API Gravity	40.60
Traded Crude:	Unknown	isobutane	0.39	Total Sulphur (% wt)	0.56
Origin:	Unknown	n-butane	1.49	Pour Point (°C)	-18.48
Sample Date:	05 March 2016	isopentane	1.08	Viscosity @ 20°C (cSt)	4.88
Assay Date:	07 March 2016	n-pentane	1.67	Viscosity @ 40°C (cSt)	3.31
Issue Date:	-	cyclopentane	0.22	Nickel (ppm)	5.6
Comments:	-	C_6 paraffins	2.83	Vanadium (ppm)	18.6
		C_6 naphthenes	2.81	Total Nitrogen (ppm)	953
		benzene	0.15	Total Acid Number (mgKOH/g)	0.05
		C_7 paraffins	3.74	Mercaptan Sulphur (ppm)	1.6
		C_7 naphthenes	2.24	Hydrogen Sulphide (ppm)	0.0
		toluene	1.37	Reid Vapour Pressure (psi)	7.7

Cut Data		Atmospheric Cuts									Vacuum Cuts			
Start (°C)	IBP	C5	65	100	150	200	250	300	350	370	370	450	500	550
End (°C)	FBP	65	100	150	200	250	300	350	370	FBP	450	500	550	FBP
Yield (% wt)		4.8	8.5	11.7	8.7	9.4	9.0	8.2	3.0	34.3	10.6	5.6	4.8	13.3
Yield (% vol)		6.1	9.8	12.5	9.2	9.5	8.9	7.8	2.8	29.8	9.8	5.0	4.2	10.8
Cumulative Yield (% wt)		2.4	7.1	15.7	27.4	36.1	45.5	54.5	62.7	65.7	65.7	76.3	81.9	86.7
Volume Average B.P. (°C)	281	44	84	124	175	225	275	324	360	528	408	474	524	662
Density @ 15°C (g/cc)	0.822	0.645	0.717	0.765	0.779	0.811	0.835	0.857	0.872	0.944	0.891	0.917	0.939	1.008
API Gravity	40.6	87.8	65.8	53.3	50.1	42.9	37.8	33.5	30.8	18.3	27.3	22.7	19.2	8.8
UOPK	12.2			11.7	11.9	11.9	11.9	11.9	12.0	12.0	12.0	12.0	12.0	11.8
Molecular Weight (g/mol)				111	148	182	222	268	304	467	356	433	493	633
Total Sulphur (% wt)	0.56	0.002	0.005	0.008	0.021	0.066	0.191	0.434	0.63	1.40	0.86	1.16	1.36	1.95
Mercaptan Sulphur (ppm)	1.6	8.9	5.7	1.8	1.8	1.7	1.2							
Total Nitrogen (ppm)	953					2	12	91	242	2732	579	1274	2033	5325
Basic Nitrogen (ppm)	226.23					2.0463	10.229	36.862	71.512	641.29	147.06	302.25	474.58	1240.9
Total Acid Number (mgKOH/g)	0.05	0.00	0.01	0.02	0.03	0.04	0.05	0.07	0.08	0.09	0.09	0.10	0.10	0.09
Viscosity @ 20°C (cSt)	4.88				1.56									
Viscosity @ 40°C (cSt)	3.31				1.14	1.79	3.10	5.91	10.1					
Viscosity @ 50°C (cSt)	2.80					1.53	2.56	4.66	7.63	293	16.5	60.6	219	
Viscosity @ 60°C (cSt)										159	12.1	38.8	122	
Viscosity @ 100°C (cSt)										26.8	4.48	10.3	22.5	838
Viscosity @ 130°C (cSt)														154
RON (Clear)	31.1	77.5	61.9	59.0	39.1									
MON (Clear)	43.0	76.8	59.7	55.0	37.4									
Paraffins (% wt)	37.8	95.4	55.7	42.4	49.2									
Naphthenes (%wt)	32.2	4.6	42.5	38.5	28.2									
Aromatics (% wt)	30.0	0.0	1.8	19.0	22.6									
Pour Point (°C)	-18					-41	-20	0	11	33	24	38	46	54
Cloud Point (°C)						-40	-18	2						
Freeze Point (°C)					-59	-37	-15							
Smoke Point (mm)					26	24	22							
Cetane Index					44	49	56	62	66					
Naphthalenes (% vol)					0.0929	1.5399	5.1773	9.1977						
Aniline Point (°C)				52.6	57.6	65.0	72.2	79.3	84.2		90.6	98.2	102.8	
Hydrogen (% wt)		16.5	15.2	14.0	14.6	14.1	13.7	13.3	13.1		12.7	12.3	12.1	
Wax (% wt)	8.2									16.4	21.8	21.1	18.6	9.2
C_7 Asphaltenes (% wt)	0.5									1.3		0.0	0.0	3.4
Micro Carbon Residue (% wt)	1.7									5.0		0.4	1.8	12.1
Rams. Carbon Residue (% wt)	1.5									4.5		0.4	1.6	10.9
Vanadium (ppm)	18.6									54.3		0.0	0.0	140.4
Nickel (ppm)	5.6									16.4		0.0	0.0	42.5
Iron (ppm)	5.1									14.8		0.0	0.0	38.3

Reference: **Crude 5**
Crude: **Crude 5**

Crude Summary Report

General Information		Molecules (%wt on crude)		Whole Crude Properties	
Reference:	Crude 5	methane + ethane	0.13	Density @ 15°C (g/cc)	0.783
Name:	Crude 5.	propane	0.64	API Gravity	49.18
Traded Crude:	Unknown	isobutane	0.42	Total Sulphur (% wt)	0.03
Origin:	United States of /	n-butane	1.26	Pour Point (°C)	-26.83
Sample Date:	-	isopentane	0.55	Viscosity @ 20°C (cSt)	2.22
Assay Date:	-	n-pentane	0.61	Viscosity @ 40°C (cSt)	1.67
Issue Date:	-	cyclopentane	0.18	Nickel (ppm)	0.1
Comments:	-	C_6 paraffins	1.60	Vanadium (ppm)	0.0
		C_6 naphthenes	3.20	Total Nitrogen (ppm)	88
		benzene	0.24	Total Acid Number (mgKOH/g)	0.03
		C_7 paraffins	6.21	Mercaptan Sulphur (ppm)	9.7
		C_7 naphthenes	1.49	Hydrogen Sulphide (ppm)	0.0
		toluene	0.47	Reid Vapour Pressure (psi)	8.0

Cut Data		Atmospheric Cuts									Vacuum Cuts			
Start (°C)	IBP	C5	65	100	150	200	250	300	350	370	370	450	500	550
End (°C)	FBP	65	100	150	200	250	300	350	370	FBP	450	500	550	FBP
Yield (% wt)		2.9	11.1	17.4	13.2	11.4	10.2	8.4	2.9	20.0	9.8	4.5	3.0	2.7
Yield (% vol)		3.5	12.0	18.4	13.5	11.1	9.7	7.8	2.7	17.7	8.8	4.0	2.6	2.3
Cumulative Yield (% wt)		2.5	5.4	16.5	33.9	47.0	58.4	68.6	77.1	80.0	80.0	89.8	94.3	97.3
Volume Average B.P. (°C)	227	48	89	125	173	225	274	324	360	464	408	474	523	599
Density @ 15°C (g/cc)	0.783	0.653	0.723	0.740	0.764	0.797	0.823	0.845	0.858	0.885	0.871	0.883	0.896	0.930
API Gravity	49.2	85.3	64.2	59.6	53.6	45.9	40.3	35.8	33.3	28.3	30.9	28.7	26.3	20.6
UOPK	12.3			12.1	12.2	12.1	12.1	12.1	12.2	12.4	12.3	12.5	12.6	12.5
Molecular Weight (g/mol)				116	148	183	223	270	307	420	361	446	512	607
Total Sulphur (% wt)	0.026	0.002	0.002	0.003	0.004	0.007	0.013	0.028	0.043	0.092	0.059	0.089	0.123	0.185
Mercaptan Sulphur (ppm)	9.7	1.2	5.0	7.9	11.5	12.7	10.3							
Total Nitrogen (ppm)	88					1	3	13	32	428	95	298	630	1641
Basic Nitrogen (ppm)	35.95					0.6897	2.3182	6.0011	10.711	173.83	24.95	75.812	193	861.8
Total Acid Number (mgKOH/g)	0.03	0.00	0.00	0.00	0.01	0.02	0.02	0.04	0.04	0.06	0.06	0.06	0.07	0.06
Viscosity @ 20°C (cSt)	2.22				2.42									
Viscosity @ 40°C (cSt)	1.67				1.74	2.68	4.21	6.99	10.4					
Viscosity @ 50°C (cSt)	1.48					2.26	3.48	5.56	8.03	32.4	13.8	35.6	93.2	
Viscosity @ 60°C (cSt)										22.9	10.5	24.9	59.7	
Viscosity @ 100°C (cSt)										7.82	4.39	8.31	15.6	60.1
Viscosity @ 130°C (cSt)														23.0
RON (Clear)	37.9	78.7	59.1	57.3	38.8									
MON (Clear)	43.1	77.7	56.6	54.5	36.9									
Paraffins (% wt)	46.9	93.9	56.2	64.8	46.6									
Naphthenes (%wt)	33.3	6.1	41.7	22.4	29.3									
Aromatics (% wt)	19.7	0.0	2.1	12.8	24.1									
Pour Point (°C)	-27					-42	-18	6	18	14	31	45	52	-6
Cloud Point (°C)						-40	-16	7						
Freeze Point (°C)					-60	-35	-12							
Smoke Point (mm)					27	21	16							
Cetane Index					51	56	62	68	74					
Naphthalenes (% vol)					0.1157	1.6315	4.8638	8.1883						
Aniline Point (°C)				48.1	55.7	68.2	80.2	92.2	100.7		112.0	124.6	131.2	
Hydrogen (% wt)		16.4	15.2	14.7	14.0	13.7	13.4	13.2	13.2		13.2	13.1	13.0	
Wax (% wt)	8.2									25.9	28.0	29.3	24.5	13.7
C_7 Asphaltenes (% wt)	0.0									0.2		0.0	0.0	1.4
Micro Carbon Residue (% wt)	0.1									0.6		0.1	0.7	3.5
Rams. Carbon Residue (% wt)	0.1									0.5		0.1	0.6	2.9
Vanadium (ppm)	0.0									0.2		0.0	0.0	1.5
Nickel (ppm)	0.1									0.6		0.0	0.0	4.4
Iron (ppm)	3.0									15.0		0.0	0.0	111.8

ATTACHMENT 2 - DETAILED EMISSION CALCULATIONS FOR CRUDE VAPOR SPECIATION

Crude Vapor Speciation - Crude Profile 1

Component	Liquid Molecular Weight (M_l)	Liquid Weight Percent (W_i)	Liquid Moles [1] (W_i/M_l)	Liquid Mole Fraction [2] $X_i = W_i/(M_t x M_l)$	Temp (°F) 73.50 Temp (°C) 23.06 Antoine's Constants (deg. C)			Vapor Pressure [3] P_i*	Partial Pressure [4] $P_i = (P_i*)(X_i)$	Vapor Mole Fraction [5] $Y_i = (P_i/P_t)$	Vapor Molecular Weight (M_v)	$(Y_i)(M_v)$	Vapor Weight Percent [6] Yi (Mv/Mt)	Max Total HAP Vapor Weight
	(lb/lb-mole)	(wt%)		(mole frac.)	A	B	C	(psia)	(psia)	(mole frac.)	(lb/lb-mole)		(wt%)	(wt%)
methane + ethane	16.00	0.02%	1.10E-05	2.05E-03	7.10	516.70	284.37	5031.02	10.34	0.45	16.00	7.21	20.22%	--
propane	44.10	0.21%	4.79E-05	0.0089	6.86	819.30	248.73	134.86	1.20	0.05	44.10	2.31	6.48%	--
isobutane	58.12	0.20%	3.44E-05	0.0064	6.82	912.10	243.34	48.03	0.31	0.01	58.12	0.78	2.18%	--
n-butane	58.12	1.15%	1.98E-04	0.0369	6.73	909.70	237.00	32.61	1.20	0.05	58.12	3.05	8.54%	--
isopentane	72.15	1.18%	1.64E-04	0.0305	6.79	1020.00	233.10	12.43	0.38	0.02	72.15	1.19	3.34%	--
n-pentane	72.15	1.70%	2.35E-04	0.0438	6.86	1070.60	232.70	9.21	0.40	0.02	72.15	1.27	3.56%	--
cyclopentane	70.10	0.08%	1.18E-05	2.19E-03	6.88	1119.20	230.74	5.68	1.25E-02	5.44E-04	70.10	3.81E-02	0.11%	--
benzene	78.11	0.22%	2.77E-05	0.0052	6.91	1211.00	220.79	1.68	0.01	3.79E-04	78.11	0.03	0.08%	0.15%
toluene	92.14	0.61%	6.65E-05	0.0124	7.02	1377.60	222.64	0.50	0.01	2.69E-04	92.14	0.02	0.07%	
crude oil	207.00	94.63%	4.57E-03	0.8517				10.64	9.06	0.40	50.00	19.77	55.41%	--
Total		M_t =	0.005					P_t =	22.92		M_t =	35.68	100.00%	

Sample Calcs for Benzene

[1] Liquid Moles (W_i/M_l) = Benzene Liquid Weight Percent (W_i) (wt%) / Benzene Liquid Molecular Weight (M_l)(lb/lb-mole)

$$\text{Liquid Moles } (W_i/M_l) = \frac{0.22\%}{} \cdot \frac{\text{lb-mole}}{78.11 \text{ lb}} = 2.77\text{E-05}$$

[2] Liquid Mole Fraction (X_i) (mole frac.) = Liquid Moles of Benzene (W_i/M_l) / Total Liquid Moles (Mt)

$$\text{Liquid Mole Fraction } (X_i) \text{ (mole frac.)} = \frac{2.77\text{E-05}}{0.005} = 0.0052$$

[3] Vapor Pressure (P_i*) (psia) = 10^(A - (B/(C+Temp (deg. C))) x 14.7 psia / 760 mmHg

[4] Benzene Partial Pressure (P_i) (psia) = Benzene Vapor Pressure (P_i*) (psia) * Benzene Liquid Mole Fraction (X_i) (mole frac)

$$\text{Benzene Partial Pressure } (P_i) \text{ (psia)} = \frac{1.68 \text{ psia}}{} \cdot \frac{0.0052}{} = 0.01 \text{ psia}$$

[5] Benzene Vapor Mole Fraction (Y_i) (mole frac) = Benzene Partial Pressure (P_i) (psia) / Total Partial Pressure (P_t) (psia)

$$\text{Benzene Vapor Mole Fraction } (Y_i) \text{ (mole frac)} = \frac{0.01 \text{ psia}}{22.92 \text{ psia}} = 3.79\text{E-04}$$

[6] Benzene Vapor Weight Percent (wt%) = Vapor Mole Fraction (Yi) (mole frac.) x Vapor Molecular Weight (Mv) (lb/lb-mole) / Σ (Yi)(Mv)

$$\text{Vapor Weight Percent (wt\%)} = \frac{3.79\text{E-04}}{} \cdot \frac{78.11 \text{ lb}}{\text{lb-mole}} \cdot \frac{1}{35.68} = 0.08\%$$

Crude Vapor Speciation - Crude Profile 2

Component	Liquid Molecular Weight (M_l)	Liquid Weight Percent (W_i)	Liquid Moles [1] (W_i/M_l)	Liquid Mole Fraction [2] $X_i = W_i/(M_t x M_l)$	Temp (°F) 73.50 / Temp (°C) 23.06 / Antoine's Constants (deg. C)			Vapor Pressure [3] P_i*	Partial Pressure [4] $P_i = (P_i^*)(X_i)$	Vapor Mole Fraction [5] $Y_i = (P_i/P_t)$	Vapor Molecular Weight (M_v)	$(Y_i)(M_v)$	Vapor Weight Percent [6] Yi (Mv/Mt)	Max Total HAP Vapor Weight
	(lb/lb-mole)	(wt%)		(mole frac.)	A	B	C	(psia)	(psia)	(mole frac.)	(lb/lb-mole)		(wt%)	(wt%)
methane + ethane	16.00	0.00%	2.10E-07	3.50E-05	7.10	516.70	284.37	5031.02	0.18	0.01	16.00	0.19	0.37%	--
propane	44.10	0.52%	1.18E-04	0.0198	6.86	819.30	248.73	134.86	2.66	0.18	44.10	7.99	15.26%	--
isobutane	58.12	0.83%	1.43E-04	0.0238	6.82	912.10	243.34	48.03	1.14	0.08	58.12	4.51	8.62%	--
n-butane	58.12	1.89%	3.25E-04	0.0542	6.73	909.70	237.00	32.61	1.77	0.12	58.12	6.98	13.33%	--
isopentane	72.15	2.36%	3.28E-04	0.0546	6.79	1020.00	233.10	12.43	0.68	0.05	72.15	3.33	6.36%	--
n-pentane	72.15	3.38%	4.68E-04	0.0780	6.86	1070.60	232.70	9.21	0.72	0.05	72.15	3.53	6.73%	--
cyclopentane	70.10	0.00%	6.53E-14	1.09E-11	6.88	1119.20	230.74	5.68	6.19E-11	4.21E-12	70.10	2.95E-10	0.00%	--
benzene	78.11	0.65%	8.31E-05	0.0139	6.91	1211.00	220.79	1.68	0.02	1.59E-03	78.11	0.12	0.24%	0.53%
toluene	92.14	2.74%	2.98E-04	0.0497	7.02	1377.60	222.64	0.50	0.02	1.68E-03	92.14	0.15	0.30%	
crude oil	207.00	87.63%	4.23E-03	0.7060				10.64	7.51	0.51	50.00	25.54	48.79%	--
Total		M_t =	0.006					P_t =	14.71		M_t =	52.35	100.00%	

Sample Calcs for Benzene

[1] Liquid Moles (W_i/M_l) = Benzene Liquid Weight Percent (W_i) (wt%) / Benzene Liquid Molecular Weight (M_l)(lb/lb-mole)

$$\text{Liquid Moles } (W_i/M_l) = \frac{0.65\%}{} \left| \frac{\text{lb-mole}}{78.11 \text{ lb}} \right. = 8.31\text{E-}05$$

[2] Liquid Mole Fraction (X_i) (mole frac.) = Liquid Moles of Benzene (W_i/M_l) / Total Liquid Moles (Mt)

$$\text{Liquid Mole Fraction } (X_i) \text{ (mole frac.)} = \frac{8.31\text{E-}05}{0.006} = 0.0139$$

[3] Vapor Pressure (P_i*) (psia) = 10^(A - (B/(C+Temp (deg. C))) x 14.7 psia / 760 mmHg

[4] Benzene Partial Pressure (P_i) (psia) = Benzene Vapor Pressure (P_i*) (psia) * Benzene Liquid Mole Fraction (X_i) (mole frac)

$$\text{Benzene Partial Pressure } (P_i) \text{ (psia)} = \frac{1.68 \text{ psia}}{} \left| \frac{0.0139}{} \right. = 0.02 \text{ psia}$$

[5] Benzene Vapor Mole Fraction (Y_i) (mole frac) = Benzene Partial Pressure (P_i) (psia) / Total Partial Pressure (P_t) (psia)

$$\text{Benzene Vapor Mole Fraction } (Y_i) \text{ (mole frac)} = \frac{0.02 \text{ psia}}{14.71 \text{ psia}} = 1.59\text{E-}03$$

[6] Benzene Vapor Weight Percent (wt%) = Vapor Mole Fraction (Yi) (mole frac.) x Vapor Molecular Weight (Mv) (lb/lb-mole) / Σ (Yi)(Mv)

$$\text{Vapor Weight Percent (wt\%)} = \frac{1.59\text{E-}03}{} \left| \frac{78.11 \text{ lb}}{\text{lb-mole}} \right| \frac{1}{52.35} = 0.24\%$$

Crude Vapor Speciation - Crude Profile 3

Component	Liquid Molecular Weight (M_l)	Liquid Weight Percent (W_i)	Liquid Moles [1] (W_i/M_l)	Liquid Mole Fraction [2] X_i = $W_i/(M_t x M_l)$	Temp (°F) 73.50 Temp (°C) 23.06 Antoine's Constants (deg. C)			Vapor Pressure [3] P_i*	Partial Pressure [4] $P_i = (P_i^*)(X_i)$	Vapor Mole Fraction [5] $Y_i = (P_i/P_t)$	Vapor Molecular Weight (M_v)	(Y_i)(M_v)	Vapor Weight Percent [6] Yi (Mv/Mt)	Max Total HAP Vapor Weight
	(lb/lb-mole)	(wt%)		(mole frac.)	A	B	C	(psia)	(psia)	(mole frac.)	(lb/lb-mole)		(wt%)	(wt%)
methane + ethane	16.00	0.03%	1.93E-05	3.54E-03	7.10	516.70	284.37	5031.02	17.82	0.57	16.00	9.05	28.89%	--
propane	44.10	0.41%	9.37E-05	0.0172	6.86	819.30	248.73	134.86	2.32	0.07	44.10	3.25	10.38%	--
isobutane	58.12	0.25%	4.38E-05	0.0081	6.82	912.10	243.34	48.03	0.39	0.01	58.12	0.71	2.28%	--
n-butane	58.12	1.27%	2.18E-04	0.0401	6.73	909.70	237.00	32.61	1.31	0.04	58.12	2.41	7.70%	--
isopentane	72.15	1.08%	1.50E-04	0.0276	6.79	1020.00	233.10	12.43	0.34	0.01	72.15	0.79	2.51%	--
n-pentane	72.15	1.63%	2.26E-04	0.0416	6.86	1070.60	232.70	9.21	0.38	0.01	72.15	0.88	2.80%	--
cyclopentane	70.10	0.05%	7.29E-06	1.34E-03	6.88	1119.20	230.74	5.68	7.62E-03	2.42E-04	70.10	1.70E-02	0.05%	--
benzene	78.11	0.76%	9.68E-05	0.0178	6.91	1211.00	220.79	1.68	0.03	9.50E-04	78.11	0.07	0.24%	0.27%
toluene	92.14	0.32%	3.42E-05	0.0063	7.02	1377.60	222.64	0.50	0.00	9.92E-05	92.14	0.01	0.03%	
crude oil	207.00	94.20%	4.55E-03	0.8365				10.64	8.90	0.28	50.00	14.13	45.12%	--
Total		M_t =	0.005					P_t =	31.50		M_t =	31.32	100.00%	

Sample Calcs for Benzene

[1] Liquid Moles (W_i/M_l) = Benzene Liquid Weight Percent (W_i) (wt%) / Benzene Liquid Molecular Weight (M_l)(lb/lb-mole)

Liquid Moles (W_i/M_l) = $\frac{0.76\%}{} \Big| \frac{\text{lb-mole}}{78.11 \text{ lb}}$ = 9.68E-05

[2] Liquid Mole Fraction (X_i) (mole frac.) = Liquid Moles of Benzene (W_i/M_l) / Total Liquid Moles (Mt)

Liquid Mole Fraction (X_i) (mole frac.) = $\frac{9.68E-05}{0.005}$ = 0.0178

[3] Vapor Pressure (P_i*) (psia) = 10^(A - (B/(C+Temp (deg. C))) x 14.7 psia / 760 mmHg

[4] Benzene Partial Pressure (P_i) (psia) = Benzene Vapor Pressure (P_i*) (psia) * Benzene Liquid Mole Fraction (X_i) (mole frac)

Benzene Partial Pressure (P_i) (psia) = $\frac{1.68 \text{ psia}}{} \Big| \frac{0.0178}{}$ = 0.03 psia

[5] Benzene Vapor Mole Fraction (Y_i) (mole frac) = Benzene Partial Pressure (P_i) (psia) / Total Partial Pressure (P_t) (psia)

Benzene Vapor Mole Fraction (Y_i) (mole frac)= $\frac{0.03 \text{ psia}}{31.50 \text{ psia}}$ = 9.50E-04

[6] Benzene Vapor Weight Percent (wt%) = Vapor Mole Fraction (Yi) (mole frac.) x Vapor Molecular Weight (Mv) (lb/lb-mole) / Σ (Yi)(Mv)

Vapor Weight Percent (wt%)= $\frac{9.50E-04}{} \Big| \frac{78.11 \text{ lb}}{\text{lb-mole}} \Big| \frac{1}{31.32}$ = 0.24%

Crude Vapor Speciation - Crude Profile 4

Component	Liquid Molecular Weight (M_l)	Liquid Weight Percent (W_i)	Liquid Moles [1] (W_i/M_l)	Liquid Mole Fraction [2] $X_i = W_i/(M_t x M_l)$	Temp (°F) 73.50 Temp (°C) 23.06 Antoine's Constants (deg. C)			Vapor Pressure [3] P_i^*	Partial Pressure [4] $P_i = (P_i^*)(X_i)$	Vapor Mole Fraction [5] $Y_i = (P_i/P_t)$	Vapor Molecular Weight (M_v)	$(Y_i)(M_v)$	Vapor Weight Percent [6] Yi (Mv/Mt)	Max Total HAP Vapor Weight
	(lb/lb-mole)	(wt%)		(mole frac.)	A	B	C	(psia)	(psia)	(mole frac.)	(lb/lb-mole)		(wt%)	(wt%)
methane + ethane	16.00	0.02%	1.26E-05	2.29E-03	7.10	516.70	284.37	5031.02	11.50	0.45	16.00	7.24	20.42%	--
propane	44.10	0.43%	9.65E-05	0.0175	6.86	819.30	248.73	134.86	2.36	0.09	44.10	4.09	11.55%	--
isobutane	58.12	0.39%	6.73E-05	0.0122	6.82	912.10	243.34	48.03	0.59	0.02	58.12	1.34	3.78%	--
n-butane	58.12	1.49%	2.57E-04	0.0466	6.73	909.70	237.00	32.61	1.52	0.06	58.12	3.47	9.80%	--
isopentane	72.15	1.08%	1.50E-04	0.0272	6.79	1020.00	233.10	12.43	0.34	0.01	72.15	0.96	2.71%	--
n-pentane	72.15	1.67%	2.32E-04	0.0420	6.86	1070.60	232.70	9.21	0.39	0.02	72.15	1.10	3.10%	--
cyclopentane	70.10	0.22%	3.13E-05	5.67E-03	6.88	1119.20	230.74	5.68	3.22E-02	1.27E-03	70.10	8.88E-02	0.25%	--
benzene	78.11	0.15%	1.96E-05	0.0035	6.91	1211.00	220.79	1.68	0.01	2.35E-04	78.11	0.02	0.05%	0.19%
toluene	92.14	1.37%	1.49E-04	0.0269	7.02	1377.60	222.64	0.50	0.01	5.27E-04	92.14	0.05	0.14%	
crude oil	207.00	93.17%	4.50E-03	0.8161				10.64	8.69	0.34	50.00	17.08	48.21%	--
Total		M_t =	0.006					P_t =	25.42		M_t =	35.44	100.00%	

Sample Calcs for Benzene

[1] Liquid Moles (W_i/M_l) = Benzene Liquid Weight Percent (W_i) (wt%) / Benzene Liquid Molecular Weight (M_l)(lb/lb-mole)

$$\text{Liquid Moles } (W_i/M_l) = \frac{0.15\% \;|\; \text{lb-mole}}{\;|\; 78.11 \text{ lb}} = 1.96\text{E-}05$$

[2] Liquid Mole Fraction (X_i) (mole frac.) = Liquid Moles of Benzene (W_i/M_l) / Total Liquid Moles (Mt)

$$\text{Liquid Mole Fraction } (X_i) \text{ (mole frac.)} = \frac{1.96\text{E-}05}{0.006} = 0.0035$$

[3] Vapor Pressure (P_i^*) (psia) = 10^(A - (B/(C+Temp (deg. C))) x 14.7 psia / 760 mmHg

[4] Benzene Partial Pressure (P_i) (psia) = Benzene Vapor Pressure (P_i^*) (psia) * Benzene Liquid Mole Fraction (X_i) (mole frac)

$$\text{Benzene Partial Pressure } (P_i) \text{ (psia)} = \frac{1.68 \text{ psia} \;|\; 0.0035}{\;|\;} = 0.01 \text{ psia}$$

[5] Benzene Vapor Mole Fraction (Y_i) (mole frac) = Benzene Partial Pressure (P_i) (psia) / Total Partial Pressure (P_t) (psia)

$$\text{Benzene Vapor Mole Fraction } (Y_i) \text{ (mole frac)} = \frac{0.01 \text{ psia}}{25.42 \text{ psia}} = 2.35\text{E-}04$$

[6] Benzene Vapor Weight Percent (wt%) = Vapor Mole Fraction (Yi) (mole frac.) x Vapor Molecular Weight (Mv) (lb/lb-mole) / Σ (Yi)(Mv)

$$\text{Vapor Weight Percent (wt\%)} = \frac{2.35\text{E-}04 \;|\; 78.11 \text{ lb} \;|\; 1}{\;|\; \text{lb-mole} \;|\; 35.44} = 0.05\%$$

Crude Vapor Speciation - Crude Profile 5

Component	Liquid Molecular Weight (M_l)	Liquid Weight Percent (W_i)	Liquid Moles [1] (W_i/M_l)	Liquid Mole Fraction [2] $X_i = W_i/(M_t x M_l)$	Temp (°F) 73.50 / Temp (°C) 23.06 — Antoine's Constants (deg. C)			Vapor Pressure [3] P_i^*	Partial Pressure [4] $P_i = (P_i^*)(X_i)$	Vapor Mole Fraction [5] $Y_i = (P_i/P_t)$	Vapor Molecular Weight (M_v)	$(Y_i)(M_v)$	Vapor Weight Percent [6] Yi (Mv/Mt)	Max Total HAP Vapor Weight
	(lb/lb-mole)	(wt%)		(mole frac.)	A	B	C	(psia)	(psia)	(mole frac.)	(lb/lb-mole)		(wt%)	(wt%)
methane + ethane	16.00	0.13%	8.06E-05	1.49E-02	7.10	516.70	284.37	5031.02	75.15	0.83	16.00	13.33	61.44%	--
propane	44.10	0.64%	1.45E-04	0.0269	6.86	819.30	248.73	134.86	3.63	0.04	44.10	1.77	8.17%	--
isobutane	58.12	0.42%	7.25E-05	0.0134	6.82	912.10	243.34	48.03	0.65	0.01	58.12	0.42	1.92%	--
n-butane	58.12	1.26%	2.16E-04	0.0401	6.73	909.70	237.00	32.61	1.31	0.01	58.12	0.84	3.88%	--
isopentane	72.15	0.55%	7.62E-05	0.0141	6.79	1020.00	233.10	12.43	0.18	0.00	72.15	0.14	0.65%	--
n-pentane	72.15	0.61%	8.49E-05	0.0157	6.86	1070.60	232.70	9.21	0.14	0.00	72.15	0.12	0.53%	--
cyclopentane	70.10	0.18%	2.54E-05	4.71E-03	6.88	1119.20	230.74	5.68	2.67E-02	2.96E-04	70.10	2.08E-02	0.10%	--
benzene	78.11	0.24%	3.04E-05	0.0056	6.91	1211.00	220.79	1.68	0.01	1.05E-04	78.11	0.01	0.04%	0.06%
toluene	92.14	0.47%	5.15E-05	0.0096	7.02	1377.60	222.64	0.50	0.00	5.26E-05	92.14	0.00	0.02%	
crude oil	207.00	95.50%	4.61E-03	0.8549				10.64	9.10	0.10	50.00	5.04	23.25%	--
Total		M_t =	0.005					P_t =	90.19		M_t =	21.70	100.00%	

Sample Calcs for Benzene

[1] Liquid Moles (W_i/M_l) = Benzene Liquid Weight Percent (W_i) (wt%) / Benzene Liquid Molecular Weight (M_l)(lb/lb-mole)

$$\text{Liquid Moles } (W_i/M_l) = \frac{0.24\%}{} \Big| \frac{\text{lb-mole}}{78.11 \text{ lb}} = 3.04\text{E-}05$$

[2] Liquid Mole Fraction (X_i) (mole frac.) = Liquid Moles of Benzene (W_i/M_l) / Total Liquid Moles (Mt)

$$\text{Liquid Mole Fraction } (X_i) \text{ (mole frac.)} = \frac{3.04\text{E-}05}{0.005} = 0.0056$$

[3] Vapor Pressure (P_i^*) (psia) = 10^(A - (B/(C+Temp (deg. C))) x 14.7 psia / 760 mmHg

[4] Benzene Partial Pressure (P_i) (psia) = Benzene Vapor Pressure (P_i^*) (psia) * Benzene Liquid Mole Fraction (X_i) (mole frac)

$$\text{Benzene Partial Pressure } (P_i) \text{ (psia)} = \frac{1.68 \text{ psia}}{} \Big| \frac{0.0056}{} = 0.01 \text{ psia}$$

[5] Benzene Vapor Mole Fraction (Y_i) (mole frac) = Benzene Partial Pressure (P_i) (psia) / Total Partial Pressure (P_t) (psia)

$$\text{Benzene Vapor Mole Fraction } (Y_i) \text{ (mole frac)} = \frac{0.01 \text{ psia}}{90.19 \text{ psia}} = 1.05\text{E-}04$$

[6] Benzene Vapor Weight Percent (wt%) = Vapor Mole Fraction (Yi) (mole frac.) x Vapor Molecular Weight (Mv) (lb/lb-mole) / Σ (Yi)(Mv)

$$\text{Vapor Weight Percent (wt\%)} = \frac{1.05\text{E-}04}{} \Big| \frac{78.11 \text{ lb}}{\text{lb-mole}} \Big| \frac{1}{21.70} = 0.04\%$$

Texas Gulf Terminals Inc.
Fugitives for the SPM System (DWP Emissions Source for PSD Applicability)
Emission Calculations

Maximum w/ Contingency (days per year)

365	days
24	hr/day

Emission Calculations [1]

Component Type	Total Number of Components [1]	Oil & Gas Emission Factor Type (lb/hr)	Fugitive Emission Factor [2] (lb/hr/ component)	Total Organic Compound lbs/hr	Total Organic Compound lbs/day	Total Organic Compound tons/project	Avg. Methane Vapor Weight % [5]	Methane Emissions [6] tons/project	CO_2e Emissions [7] tons/project
Valves	8	Light Liquid (Light Oil > 20° API)	5.50E-03	4.40E-02	1.06	0.19	26%	0.05	1.25
Flanges	26	Light Liquid (Light Oil > 20° API)	2.43E-04	6.32E-03	0.15	2.77E-02	26%	0.01	0.18
	Total TOC [4] - Heavy Oil Streams			**0.05**	**1.21**	**0.22**	**--**	**0.06**	**1.43**

Notes:

[1] Component counts are based on Engineering design information provided by Lloyd Engineering to Trinity Consultants on April 12, 2018.

[2] Emission Factors were obtained from *Table 4. Average Emission Factors - Petroleum Industry* (Oil & Gas Production Operations) of TCEQ's Addendum to RG-360A, Emission Factors for Equipment Leak Fugitives Components, January 2008.

[3] Fugitive emissions are conservatively estimated to be 100% VOC.

[4] Annual operating hours are conservatively assumed to be 8,760 hours per year.

[5] Methane vapor weight fraction is based on crude composition data.

[6] Methane Annual Emissions (tpy) = Max Methane % in Crude/Condensate Vapors x TOC Annual Emissions (tpy)

$$\text{Methane Annual Emissions from Valves (tpy)} = 26\% \times \frac{0.19 \text{ tons}}{\text{yr}} = 0.05 \text{ tpy}$$

[7] Global Warming Potential (GWP) of 25 for methane obtained from Appendix Table A-1 of 40 CFR Part 98.

$$CO_2\text{e Annual Emissions from Valves (tpy)} = \frac{0.05 \text{ tons}}{\text{yr}} \times 25 = 1.25 \text{ tpy}$$

ATTACHMENT 3 - GHG EMISSIONS CALCULATION FOR MARINE LOADING AND SPM FUGITIVES

Texas Gulf Terminals Inc.
Normal Operations Emissions Summary - Crude Carrier, Support Vessels & boats

Annual Emissions Summary (tons/year)

Emission Unit ID	Emission Unit	NSR Regulated Air Pollutants & Greenhouse Gas Emissions (CO_2e)											Hazardous Air Pollutants (HAPs)
		PM	PM_{10}	$PM_{2.5}$	NO_x	SO_2	H_2SO_4	CO	VOC	H_2S	Pb	CO_2e	Total VOC HAPs
		tons/yr	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr
DWP Emissions Source for PSD Applicability													
Marine Loading	Marine Loading								10,808	0.24		70,251	2.00E+02
SPM Fugitive	SPM Fugitive								0.22			1	
Indirect Emission Sources													
Tug Boat - Supply Boat Main Engines	Tug Boat - Supply Boat Main Engines	9.94	5.70	5.53	183.29	10.62	3.32E-01	78.14	9.11		2.88E-03	16,271	1.69E-01
Tug Boat Aux Engine	Tug Boat Aux Engine	0.21	0.21	0.21	4.69	0.32	1.01E-02	3.55	1.09		8.77E-05	495	1.20E-02
Pilot Boats	Pilot Boats	0.91	0.52	0.50	4.28	0.97	3.03E-02	7.13	0.83		2.63E-04	1,484	1.55E-02
Helicopter	Helicopter	0.00	0.00	0.00	0.05	0.01	0.00E+00	0.14	0.10		0.00E+00	11	6.90E-02
Carrier Main Engine	Carrier Main Engine	27.57	27.57	25.34	728.02	16.95	5.29E-01	65.95	14.54		4.60E-03	25,955	2.70E-01
Carrier Aux Engine	Carrier Aux Engine	4.67	2.68	2.60	110.26	4.99	1.56E-01	36.71	4.28		1.35E-03	5,096	5.31E-02
Crane Engine	Crane Engine	2.21	1.27	1.23	51.06	2.36	7.37E-02	17.36	2.03		6.41E-04	3,615	3.77E-02
Carrier Boiler	Carrier Boiler	8.09	8.09	8.09	58.83	34.81	0.00E+00	12.26	0.49		3.09E-03	56,146	1.69E-01
Cargo Pumps	Cargo Pumps	10.89	6.24	6.05	373.25	11.63	3.63E-01	85.54	9.98		3.16E-03	17,812	1.86E-01
Stripping Pumps	Stripping Pumps	0.29	0.17	0.16	9.95	0.31	9.69E-03	2.28	0.27		8.42E-05	475	4.95E-03
Ballast Pumps	Ballast Pumps	4.35	2.50	2.42	149.30	4.65	1.45E-01	34.21	3.99		1.26E-03	7,125	7.42E-02
TOTAL Normal Operation Scenario (Worst Case)		**69.1**	**54.9**	**52.1**	**1673.0**	**87.6**	**1.65E+00**	**343.3**	**10,855**	**0.24**	**1.74E-02**	**134,484**	**201.1**

Texas Gulf Terminals Inc.
Normal Operations Emission Calculations
Marine Loading (DWP Emissions Source for PSD Applicability)
Greenhouse Gas Emissions

Parameter	Value	Unit
Avg. methane vapor weight % in Crude Oil [1]	26%	

[1] Methane vapor weight fraction is based on crude composition data.

Pollutant	Liquid Loaded [1]	TOC Annual Emissions (tpy)	Annual Emissions [2],[3] (tpy)
Methane	Crude Oil	10,365	2,695
	Condensate	10,808	2,810
CO_2e	Crude Oil	--	67,372
	Condensate	--	70,251

[1] For annual emission estimates, the worst-case marine loading commodity between Crude oil and Condensate will be utilized.

[2] Methane Annual Emissions (tpy) = Max Methane % in Crude/Condensate Vapors x TOC Annual Emissions (tpy)

$$\text{Methane Annual Emissions from Crude Oil (tpy)} = \frac{26\%}{} \cdot \frac{10{,}365\ \text{tons}}{\text{yr}} = 2{,}695\ \text{tpy}$$

[3] Global Warming Potential (GWP) of 25 for methane obtained from Appendix Table A-1 of 40 CFR Part 98.

$$CO_2e\ \text{Annual Emissions from Crude Oil (tpy)} = \frac{2{,}695\ \text{tons}}{\text{yr}} \cdot \frac{25}{} = 67{,}372\ \text{tpy}$$

Texas Gulf Terminals Inc.
Fugitives for the SPM System (DWP Emissions Source for PSD Applicability)
Emission Calculations

Maximum w/ Contingency (days per year)

365	days
24	hr/day

Emission Calculations [1]

Component Type	Total Number of Components [1]	Oil & Gas Emission Factor Type (lb/hr)	Fugitive Emission Factor [2] (lb/hr/ component)	Total Organic Compound lbs/hr	Total Organic Compound lbs/day	Total Organic Compound tons/project	Avg. Methane Vapor Weight % [5]	Methane Emissions [6] tons/project	CO_2e Emissions [7] tons/project
Valves	8	Light Liquid (Light Oil > 20° API)	5.50E-03	4.40E-02	1.06	0.19	26%	0.05	1.25
Flanges	26	Light Liquid (Light Oil > 20° API)	2.43E-04	6.32E-03	0.15	2.77E-02	26%	0.01	0.18
	Total TOC [4] - Heavy Oil Streams			0.05	1.21	0.22	--	0.06	1.43

Notes:

[1] Component counts are based on Engineering design information provided by Lloyd Engineering to Trinity Consultants on April 12, 2018.

[2] Emission Factors were obtained from *Table 4. Average Emission Factors - Petroleum Industry* (Oil & Gas Production Operations) of TCEQ's Addendum to RG-360A, Emission Factors for Equipment Leak Fugitives Components, January 2008.

[3] Fugitive emissions are conservatively estimated to be 100% VOC.

[4] Annual operating hours are conservatively assumed to be 8,760 hours per year.

[5] Methane vapor weight fraction is based on crude composition data.

[6] Methane Annual Emissions (tpy) = Max Methane % in Crude/Condensate Vapors x TOC Annual Emissions (tpy)

$$\text{Methane Annual Emissions from Valves (tpy)} = 26\% \times \frac{0.19 \text{ tons}}{\text{yr}} = 0.05 \text{ tpy}$$

[7] Global Warming Potential (GWP) of 25 for methane obtained from Appendix Table A-1 of 40 CFR Part 98.

$$CO_2e \text{ Annual Emissions from Valves (tpy)} = \frac{0.05 \text{ tons}}{\text{yr}} \times 25 = 1.25 \text{ tpy}$$

ATTACHMENT 4 - COMPARISON OF CRUDE/CONDENSATE EMISSIONS BETWEEN EQUATIONS 1 AND 2 OF AP-42 CHAPTER 5.2

A comparison of emissions between Equations 1 and 2 of AP-42 Chapter 5.2 for crude oil and condensate is shown in the table below.

Liquid Loaded [1]	Loading Calculation	Compartment Condition Prior to Loadng	Saturation Factor [2]	Maximum Temp [3]		Vapor MW	Maximum True Vapor Pressure (TVP) [4]	Arrival Emission Factor [5]	Generated Emission Factor [6]	Uncontrolled Loading Loss [7]	TOC to VOC Factor	Hourly Loading Rate [8]	Uncontrolled VOC Hourly Emissions [9]
				(°F)	(°R)	(lb/lb mol)	(psia)	(lb/1,000 gal)	(lb/1,000 gal)	(lb/1,000 gal)		(bbl/hr)	(lb/hr)
Crude Oil	AP-42 Ch 5.2, Eq 1 - API	Volatile Uncleaned	0.2	73.5	533.2	50	11	--	--	2.57	1	60,000	6,478.07
Crude Oil	AP-42 Ch 5.2, Eq 2-3	Volatile Uncleaned	--	73.5	533.2	50	11	0.86	0.78	1.64	0.85	60,000	3,508.46
Condensate	AP-42 Ch 5.2, Eq 1 - API	Volatile Uncleaned	0.2	73.5	533.2	60	11	--	--	3.08	1	60,000	7,773.68
Condensate	AP-42 Ch 5.2, Eq 2-3	Volatile Uncleaned	--	73.5	533.2	60	11	0.86	0.93	1.79	0.85	60,000	3,841.73

[1] For hourly emission estimates, the worst-case marine loading commodity between Crude oil and Condensate will be utilized.
[2] Saturation factor for marine loading obtained from U.S. EPA 42, Section 5.2 (1/95), Table 5.2-1.
[3] Maximum of monthly average liquid surface temperature was used.
[4] Maximum true vapor pressure for Crude oil and Condensate obtained from information provided by Texas Gulf Terminals
[5] Arrival emission factor for crude/condensate loading obtained from U.S. EPA 42, Section 5.2 (1/95), Table 5.2-3.
[6] Generated emission factor is calculated using Equation 3 from U.S. EPA 42, Section 5.2 (1/95).
[7] Uncontrolled Loading Loss (lb/1,000 gal) = 12.46 x Saturation Factor x Maximum TVP of Liquid Loaded (psia) x Vapor MW (lb/lbmol) / Maximum Temperature of Bulk Liquid Loaded (°R)
[8] Hourly Loading Rate obtained from information provided by TGTI Revised Design Parameters email from Ms. Denise Rogers (TGTI) to Mr. Brian Burdorf (Trinity Consultants) on February 25, 2018.
[9] Uncontrolled VOC Hourly Emissions (lb/hr) = Uncontrolled Loading Loss (lb/1,000 gal) x Hourly Loading Rate (bbl/hr) x 42 gal/bbl x TOC to VOC Factor x (1/1,000)

ATTACHMENT 5 - REFERENCE FOR EQUATION 3 OF AP-42 CHAPTER 5.2

API Manual of Petroleum Measurement Standards
Chapter 19.5
(Formerly, API Publication 2514A)

EI Hydrocarbon Management
HM 65

Atmospheric hydrocarbon emissions from marine vessel transfer operations

1st edition, September 2009

API MPMS Chapter 19.5/EI HM 65

Atmospheric hydrocarbon emissions from marine vessel transfer operations

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Foreword

This publication was prepared jointly by the American Petroleum Institute Committee on Petroleum Measurement and the Energy Institute Hydrocarbon Management Committee. This standard supersedes API Publication 2514A, Second Edition, September 1981, which is withdrawn. See A.1 for more information on the previous editions of this document.

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Atmospheric hydrocarbon emissions from marine vessel transfer operations

1 Scope

This standard provides methods for estimating evaporative loss from marine vessel transfer operations. Specifically, this standard addresses:

1) loading stock into:

    a) ship or ocean barges, or

    b) shallow draft barges, and

2) loading ballast water into ship or ocean barges from which crude oil has been unloaded.

The emission estimates are for uncontrolled loading operations and do not apply to operations using vapor balance or vapor control systems or ballasting of ships with segregated ballast tanks.

This standard does not address evaporative loss for:

1) very large crude carriers (VLCCs) or ultra large crude carriers (ULCCs) (unless the saturation factor K_S is determined);

2) marine vessels employing crude oil washing (see 3.3.1);

3) marine vessel transit loss;

4) loading ballast water into marine vessels that, prior to dockside unloading, held anything other than crude oil (unless the saturation factor K_S is determined); or

5) unloading marine vessels.

This standard supersedes API 2514A, Second Edition, September 1981, which is withdrawn.

2 References

[1] American Petroleum Institute, *Recommended Practice for Specification of Evaporative Losses*, *Manual of Petroleum Measurement Standards*, Chapter 19, Section 4, Second Edition, September 2005

[2] American Petroleum Institute, Publication 2524, *Impact Assessment of New Data on the Validity of American Petroleum Institute Marine Transfer Operation Emission Factors*, July 1992

[3] American Petroleum Institute, Publication 2514A, *Atmospheric Hydrocarbon Emissions from Marine Vessel Transfer Operations*, Second Edition, September 1981

[4] Spectrasyne Ltd., "Studies of VOC Emissions from External Floating Roof Tanks and Barge Loading—November 1993," Spectrasyne Report No. TR9413, prepared for CONCAWE, Brussels, Belgium, June 13, 1994

[5] CONCAWE, "VOC Emissions from External Floating Roof Tanks: Comparison of Remote Measurements by Laser with Calculated Methods," CONCAWE Report No. 95/52, January 1995